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Original Research

Preoperative factors affecting the intraoperative core body temperature in elective hysterectomy under general anesthesia

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Summary

Background: Hypothermia is common in patients undergoing anesthesia surgery and it may increase the potential risk of post-operative complications. The purpose of this study was to investigate the intraoperative factors that affect the core temperature of women after hysterectomy. *Materials and Methods:* One hundred and four female patients aged 18 and older, who were treated with elective open hysterectomy, were studied. The authors evaluated the incidence of hypothermia with respect to demographics, clinical, and anesthesia characteristics in two patients groups (hypothermic *vs*. normothermic). *Results:* The incidence of intraoperative hypothermia was 53.8. Advanced age (OR=6.449; 95% CI 3.603-14.397, $p < 0.001$), higher BMI (OR=5.879; 95% CI 5.122-7.325), higher intraoperative core body temperature (OR=0.483; 95% CI 0.432-0.578), large surgeries (OR=4.149; 95% CI 3.549-5.881, $p < 0.001$), and the number of opioids (OR=0.199; 95% CI 0.084-0.428) were found to be the most important predictors for hypothermia intraoperatively. There was significant statistical difference between the two groups with respect to American Society of Anaesthesiologists' (ASA) score, induction to anesthesia with propofol and sevoflurane, and the administration of muscle relaxants perioperatively. *Conclusions:* The application of an appropriate, simple, and low-cost heating method, either by administrating warmed intravenous fluids or using an air-heating flow device, can help to prevent surgical patients' hypothermia and its possible dangerous complications.

Key words: Preoperative factors; Intraoperative temperature; Hysterectomy.

Introduction

Hysterectomy is one of the most important surgeries in developed countries with prevalence which varies by race and geographical area from 4% to 40% [1-3]. In Greece, ovarian cancer is the fifth cause of death among female cancers (6.2/100.000), while the corpus uteri (2.6/100.000) and the cervix uteri (2.5/100.000) cancers are the tenth and 11th cause of death [4]. The incidence for ovary cancer in Greece is 11.3, for corpus uteri cancer is 10 and for cervix cancer uteri is 6.2 [4]. Almost, all of these women undergo hysterectomy, a surgical procedure that removes the uterus and often the fallopian tubes, the ovaries and the cervix [5].

Hypothermia is common in patients undergoing anesthesia surgery. During general anesthesia, the thermoregultatory mechanism is suppressed and reduces heat production (inhibiting the vasoconstriction), while increasing heat loss, resulting in lower body temperature. The temperature of core of surgical patients is usually reduced from 0.5°C to 1.5°C in the first hour of anesthesia [6].

Hypothermia can cause side effects during surgery and increase the risk of postoperative complications such as reduced wound healing, surgical infections, cardiovascular disorders, increased respiratory distress, and altered drug metabolism [7]. The aim of this study was to investigate the intraoperative factors that affect the core temperature of women after hysterectomy.

Materials and Methods

Female patients aged 18 and older, diagnosed with either ovary cancer or corpus uteri cancer or cervix cancer were treated with elective open hysterectomy at the Surgical Clinic of Nikaia General Hospital in Athens, Greece, between January 2016 and June 2016. Ethics approval and consent to participate was obtained from each participant before participation.

From the study were excluded patients who were not admitted in the post-anesthesia care unit (PACU) but were transferred directly to the intensive care unit (n = 6), patients whose temperature was not taken for any reason intraoperatively (n=3), patients with thyroid gland disorders (n = 4), and patients with ASA 5 and 6 classification (n = 2). In total, 15 patients were excluded from the study.

According to the Association of perioperative Registered Nurses (AORN), hypothermia occurs when the core body temperature is below 36°C or 96.8 °F [6]. Therefore, all patients who had core body temperature below 36°C were considered as hy-

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Table 1. — *Patients' demographic and clinical characteristics.*

Variables	n (%)
BMI	
Normal	52 (50)
Overweight	15 (14.4)
Obese	37 (35.6)
ASA score	
I	91 (87.5)
II	13 (12.5)

Table 2. — *Anesthesia characteristics.*

Variables	n (%)
Type of anesthesia	
Inhalation	13 (12.5)
Intravenous	13 (12.5)
Combination	78 (75)
Anesthetic drug	
Desoflurane	13 (12.5)
Propofol	13 (12.5)
Propofol and desoflurane	26 (25)
Propofol and sevoflurane	52 (50)
Opioid drugs	
Fentanyl	99 (95.2)
Fentanyl and remifentanyl	5 (4.8)
Premedication	54 (51.9)
Local anesthetic, ropivacaine	44 (42.3)
Muscle relaxants	32 (30.8)

Table 3. — *Incidence of hypothermia.*

Variables	n (%)
Intraoperatively	56 (53.8)
Admission to PACU	86 (82.7)
Discharge from PACU	94 (90.4)

pothermics. The authors had three temperature measures in total: the first was during the surgical procedure (intraoperatively), the second was at the admission to the PACU, and the last was at the discharge of the PACU. The temperature of the core of patients was measured with an electronic tympanic thermometer type. Every morning and before surgery, the thermometer was calibrated according to the manufacturer's instructions in order to achieve the highest possible accuracy of the measurements. Thus, there were two patients groups (hypothermic *vs*. normothermic). Patient and clinical characteristics including age, BMI, ASA score, duration of surgery, type of anaesthesia, and drugs related to anesthesia were compared between the groups. Patients were classified as normal weight (BMI = 18.5-24.9), overweight (BMI = 25-29.9), and obese (BMI ≥ 30) [8].

Univariate comparisons for the groups (normothermics *vs*. hypothermics) differences were performed using chi-squared tests for equal proportion, ANOVA for continuously normally distributed variables and Kruskal–Wallis tests in different cases. Pearson and Fisher exact tests were used for categorical variables. Multivariate analysis was performed by the Cox proportional hazards regression analysis. Results with a p-value < 0.05 were considered statistically significant.

Results

The sample size consisted of 104 women who underwent hysterectomy. The mean patient age was 40.8 ± 14.5 years. The demographic and clinical characteristics of patients are shown in Table 1.

Most of the patients received inhalation and intravenous anesthesia. Combination of sevoflurane and propofol was administered to half of the patients, while almost all patients received fentanyl. Moreover, 51.9% of the patients received premedication before the induction to anesthesia. The patients also received 0 ± 0.8 opioids and the duration of the surgery was 105.2 ± 15.4 min. The characteristics of the anesthesia, including drugs, are shown in Table 2.

Patients' core body temperature (CBT) was 35.8 ± 0.3°C intraoperatively. Furthermore, patients' CBT was 35.6 ± 0.3°C during the admission to PACU, and at the discharge from PACU it was 35.7 ± 0.4°C. The incidence of hypothermia during the three measured periods is shown in Table 3.

Multivariate regression analysis showed that the age (OR = 6.449; 95% CI: 3.603-14.397, $p < 0.001$), BMI (OR = 5.879; 95% CI: 5.122-7.325), CBT intraoperatively (OR = 0.483; 95% CI: 0.432-0.578), duration of surgery (OR = 4.149; 95% CI: 3.549-5.881, $p < 0.001$), and the number of opioids (OR = 0.199; 95% CI: 0.084-0.428) were the most important predictors for hypothermia during surgery. The results of the multivariate analysis are shown in Table 4.

The patients who were hypothermic at the admission to PACU were administered significantly more opioids (0.9 ± 0.4 *vs*. 0.5 ± 0.6, $p = 0.036$), and muscle relaxants (37.2% *vs*. 0, $p = 0.028$) perioperatively. Moreover, some factors for patients hypothermia at discharge from PACU were a) advanced age (61.6 ± 12.1 *vs*. 52.1 ± 9.4, $p = 0.000$), b) duration of surgery (111.3 ± 12.1 *vs*. 96.1 ± 8.8 min, $p = 0.001$), and c) CBT at discharge from PACU (35.6 ± 0.3 *vs*. 36.5 ± 0.2°C, $p = 0.000$).

Discussion

To the present authors' knowledge, this is the first study that is focused on this target group. There are some studies that investigate the intraoperative hypothermia to patients with hysterectomy, but the sample size is very small and this kind of patients comprises a small part of the whole sample, usually about 3-5% [9-11].

Normal body temperature ranges from 36.5°C to 37.5°C [12]. Hypothermia is a phenomenon that can be caused by heat loss due to prolonged exposure to cold conditions (environment and fluids), thermoregulation, vasodilation disorders, and muscle tone loss as a result of anesthetic or local anesthesia administration [13].

The incidence of hypothermia intraoperatively in different types of surgical interventions has been reported from 4% to 90% [14, 15]. In the present study, intraoperative hy-

Table 4. — *Multivariate analysis between two groups.*

Variables	Normothermia (n=48)	Hypothermia (n=56)	Odds ratio	95% Confidence Interval	*p*-value
Age, years	46 ± 9.3	57 ± 11.1	6.449	3.603-14.397	0.000
BMI, kg/m^2	30.1 ± 9.9	27.2 ± 8.7	5.879	5.122-7.235	0.000
ASA score	1 ± 0.2	1.3 ± 0.4	0.174	0.095-0.405	0.002
CBT intraoperatively	36.2 ± 0.1	35.6 ± 0.2	0.483	0.432-0.578	0.000
Anesthetic drug, propofol and sevoflurane	48 (100)	19 (33.9)	1.512	0.308-2.358	0.013
Duration of surgery	97.2 ± 10.1	111.4 ± 11.8	4.149	3.549-5.881	0.000
Number of opioids	0.7 ± 0.5	1 ± 0.4	0.199	0.084-0.428	0.000
Muscle relaxants	8 (16.7)	24 (42.9)	0.224	0.088-0.436	0.013

pothermia was detected in about 54% of the patients.

In an international study carried out in China on surgical procedures most of which were general and gynecological, the overall incidence of intraoperative hypothermia was 44.3% [9]. The incidence of hypothermia in large abdominal interventions but not hysterectomy in two studies, was found to be 65% to 74% [16, 17]. One other study showed that 72% of the patients who had undergone open abdominal surgery experienced hypothermia intraoperatively [18]. The difference of these incidences may be due to the complexity of surgical procedures and the duration of anesthesia.

In elective surgical interventions in 493 patients, 21.3% were found to have intraoperative hypothermia [19], while in another study hypothermia amounted to 39.1% [20]. Yang *et al.* [21] showed that in 1,840 patients, the presence of hypothermia under general anesthesia was 25.7%.

Petsas *et al.* [22] found in 226 cesarean sections that the mean temperature of women intraoperatively was 36°C and that half of all patients undergoing cesarean section had a lower temperature than recommended by the National Institute of Clinical Excellence guidelines.

The incidence of hypothermia varies widely, possibly partly due to differences in definitions of hypothermia, the time, and the site that temperature is being recorded [23-25]. In order to avoid an underestimation of the incidence of hypothermia, in the present study the temperature measurement was performed in the middle of the surgical procedure [25, 26].

The present authors found that advanced age, larger BMI, larger ASA score, lower intraoperative CBT, muscle relaxants, duration of surgery, and the number of opioids were risk factors for developing intraoperative hypothermia.

In the literature and in accordance with the results of this study, many risk factors for the development of intraoperative hypothermia are identified, including aging, female gender, depth of anesthesia, type of surgery, duration of anesthesia, operating temperature, very low or high weight of patients, and the administration of cold fluids [13, 27].

In agreement with the results of this study, older patients have normal predisposition to develop hypothermia [17, 28-30]. In the elderly, decreased release of norepinephrine and the decreased response of a-adrenergic receptors reduce the vasomotor response to cold. In addition, loss of lean body mass due to aging reduces shivering and hence metabolic heat production [31].

Yi *et al.* [9], in agreement with the results of the present study, found that increased BMI is a risk factor of hypothermia. Obese people have body fat with low thermal conductivity that reduces heat loss from the skin, reducing the likelihood of hypothermia [32]. They have higher levels of leptin but have greater peripheral resistance to the action of this protein [33]. Leptin is secreted by adipocytes and has several physiological roles that include increasing sympathetic nervous system activity, which stimulates energy consumption in brown lipid tissue and increases the rate of metabolism and hence body heat [34].

Patients with ASA scores III and IV have been reported to have an increased risk of hypothermia [35]. Although most studies classify patients with the ASA system, no further reference was made to its relationship to hypothermia. The present authors found that patients who had hypothermia intraoperatively, had increased ASA score. However, there are no data for categories III or IV because the patients who participated in the study had ASA score I or II.

It is known that heat loss is higher and hypothermia is more common in large surgeries [29]. A study carried out at a hospital in Sao Paulo aimed at identifying factors associated with the development of intraoperative hypothermia, showed a statistically significant difference between mean body temperature and duration of surgery [29, 30]. In accordance with the results reported in the literature [9,10, 29-31, 36], the present found that the increased duration of surgery was associated with increased incidence of hypothermia intraoperatively.

Intramuscular administration of midazolam produces a dose-dependent decrease in core temperature and causes vasodilation and redistribution of heat from the core to the periphery. Midazolam at a dose of 0.025 mg / kg is not associated with hypothermia, while the core temperature of patients treated with midazolam 0.075 mg / kg was reduced by 0.5°C, 30 minutes after the administration [37]. In the present study, core temperature in patients treated with midazolam was statistically significantly lower than those with no premedication, which is in agreement with the literature [38]. Also, the present authors found that the administration of opioids is a risk factor for hypothermia. This result is consistent with other studies, but the mechanism

has not yet been elucidated [39-41].

In the case of patients undergoing open-abdominal surgery, various factors may lead to the development of perioperative hypothermia such as extended area of the patient's body exposed to the temperature of the operation room (abdomen and upper extremities) [29].

The temperature of the operating room is another important factor that affects the core body temperature. Temperature in operating rooms is recommended to be between 22ºC and 24ºC, regardless of the type of surgery. Surgery performed at temperatures below 21°C may cause hypothermia in patients. In order to avoid this intraoperative complication, it is recommended to use thermal blankets or layers [42].

One main factor reported in the literature as responsible for the development of intraoperative hypothermia, yet not examined in this study, is patients' higher core temperature before surgery (9, 42]. Another risk factor for intraoperative hypothermia is the administration of intravenous fluids of more than 1,000 ml [9, 36].

During the operative period, hypothermia can also be caused by systemic disorders. It may also be associated with metabolic diseases and neurological disorders. Some systemic disorders, such as hypothyroidism, may decrease the core body temperature [43, 44]. This is the reason why patients with these diseases were excluded from the study.

The present study had some limitations. The temperature in the operation rooms was not standardized, which could cause confusion in the results. Also, the operation room temperature was not measured and not recorded during the study period, a factor that may affect the patient's intraoperative temperature.

The way the temperature was taken is itself a weak point of the study. Patients' temperature was obtained by infrared tympanic thermometer. One study comparing the "gold standard" of a pulmonary artery thermistor with infrared tympanic thermometers, indicated that tympanic thermometers showed a temperature of 0.1-0.4% less than the thermistor [45]. Therefore, the frequency of hypothermia may have been overestimated because infrared tympanic thermometers are less accurate than thermistors [46].

Conclusions

This is the first study that included only elective hysterectomy patients. The incidence of hypothermia intraoperatively was 54%. The factors responsible for the occurrence of hypothermia intraoperatively were advanced age, large BMI, high ASA score, increased surgical duration, and administration of opioid and muscle relaxation.

The application of an appropriate, simple and low-cost heating method, either by administrating warmed intravenous fluids or using an air-heating flow device, can help to prevent surgical patients' hypothermia and its possible dangerous complications. Therefore, healthcare professionals could prevent these complications by monitoring vital signs, especially temperature of the patients in the operation room and ensuring that warmed intravenous fluids are present in each surgery.

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